TERMA

UPDATE

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Royal Norwegian Air Force selects Terma for Installation of Missile Warning System on F-16

Norwegian Air Force F-16, carrying pylon mounted missile warning sensors on stations 3 and 7. Six sensors provide 360 deg coverage against incoming IR guided missiles. The GBU 24\B illustrates that the pylon retains full weapons carrying capability.

CONTENTS: **Royal Norwegian Air Force** Selects Terma for Installation of **Missile Warning System on F-16** / 2 // **SCANTER 4002** Wind Farm Air Surveillance / 4 // Terma Airborne System **Expands** Business Area to Include **South America** / 6 // Matured Decision Support and High Fidelity Embedded Training **- a Vision Come Through** / 7

In this Update issue:

The Royal Norwegian Air Force selects Terma for installation of Missile Warning System, MWS, on F-16. After successful development program in Denmark for the pylon mounted MWS installation, the Norwegian Air Force has now ordered the same solution for their F-16s.

Over the past seven years, the five European F-16 countries, Portugal, Belgium, The Netherlands, Denmark and Norway have together with Terma successfully expanded the AN/ALQ-213 Electronic Warfare Management System to include operationally tested Matured Decision Support and Embedded Training capabilities

The concerns about air safety in proximity of wind farms are finally addressed by introducing the SCANTER 4002 as a cost-effective gap-filling air surveillance radar. The SCANTER 4002 provides inter-turbine visibility and enables tracking of small targets inside and around wind farms.

Norwegian F-16 equipped with Pylon mounted Missile Warning System. 3 missile warning sensors on each pylon, stations 3 & 7 provide near 360 deg spherical coverage against missile attack. Also illustrated is the pylon's ability to retain full weapons load capability, here the GBU 24 \B.

Royal Norwegian Air Force Selects Terma for Installation of Missile Warning System on F-16

By John Rygaard

After a successful development program in Denmark for the pylon-mounted MWS installation, the Norwegian Air Force has now ordered the same solution for their F-16's. Since the F-16 was developed in the 1970's the threat has changed considerably, from that of weapons guided by fire control radars, to infrared homing missiles. These missiles exist in great numbers, they are easy to operate and in terrorist hands, they pose a serious threat to aircraft operating in conflict areas, and over time quite a number of aircraft have been lost in IR missile attacks. It is therefore of vital importance that aircraft operating in these areas be equipped with missile warning systems and the corresponding countermeasures. For quite some years, such systems have been in operation on helicopters and transport aircraft, but only within the recent few years has it been possible to overcome the problems connected with fast jets, such as very high speeds, high G loads, vibrations, interference from afterburners, own weapons and other aircraft in the formation. These problems have now been overcome and reliable Missile Warning Systems for fast jets are on the market.

Six pylon-mounted sensors provide 360 deg spherical coverage

The solution chosen for the Danish, and now the Norwegian F-16's, is based on a derivative of the Terma developed Pylon Integrated Dispensing System, PIDS+. Pylons on stations 3 and 7 are equipped with each 3 Missile Warning Sensors, giving near 360 deg spherical coverage against missile attack. This solution was tested already in 1998, when the European F-16 users and US Air National Guard conducted a feasibility program to evaluate if a Missile Warning System installation like that could perform satisfactorily. The conclusion was that the concept was very cost-effective compared to a fuselage installation, and that the performance fulfilled the requirements, After the feasibility study, the Danish Air Force, later to be the launch customer, tasked Terma to develop the integration of the MWS hardware in the pylons and develop system control software for the ALQ-213 EWMS including display and 3D-Audio. The system is now installed and fully certified by the US Air Force Seek Eagle Office on the F-16.

Cost-effective solution

Mounting of the Missile Warning sensors in the weapons pylons offers important advantages: installation is done on pylons rather than on the aircraft structure, which reduces aircraft down time for modification considerably and fewer systems are needed because pylons can be rotated within the fleet. These factors lead to considerably reduced overall cost. At the same time it is possible to retain two chaff/flare magazines in each PIDS+ pylon, giving overall increased survivability.

AN/ALQ-213(V)

The Terma EW Management System AN/ALQ-213(V) was already in the Norwegian F-16s and from its birth prepared for installation of a missile warning system. I was therefore relatively uncomplicated to install the Missile Warning System control software. A new full color Advanced Threat Display, ATD replaced the old IP 1310 RWR display and a Countermeasures Signals Processor, CSP, has been installed for correlation and threat declaration of signals from the six sensors. The pilot is alerted to the threat by indication on the ATD, by a symbol on the HUD and through a voice message. Once a missile has been declared hostile, flares will automatically be fired, provided the pilot has selected the automatic mode on his EW management unit.
By the Royal Norwegian Air Force, this program is considered an important factor in keeping the F-16's combat ready for possible conflicts in the coming years.

Warning of missile attack will appear on the Advanced Threat Display.

Each pylon is equipped with one missile warning sensor in the nose and two in the tail.

Wind farm at Horns Rev1 (photo: Dong Energy A/S)

SCANTER 4002
Wind Farm Air Surveillance

By Michael Agergaard Riis

The concerns about air safety in proximity of wind farms are finally addressed by introducing the SCANTER 4002 as cost-effective gap-filling air surveillance radar. The SCANTER 4002 provides inter-turbine visibility and enables tracking of small air targets inside and around wind farms.

The challenge

When wind turbines are grouped in large wind farms they can have a significant effect on radars and specifically on radars used for aviation as they are typically designed to show only moving objects and filter out anything stationary. The spinning blades of the wind turbines can appear on the radar screen as false "targets". The interference (or "clutter") generated by the turbines can desensitize the radar in the area of the wind farm causing legitimate targets to disappear. This in turn can affect the deployment of wind farms and several planned wind farms have already been delayed significantly or even cancelled.

SCANTER 4002 transceiver

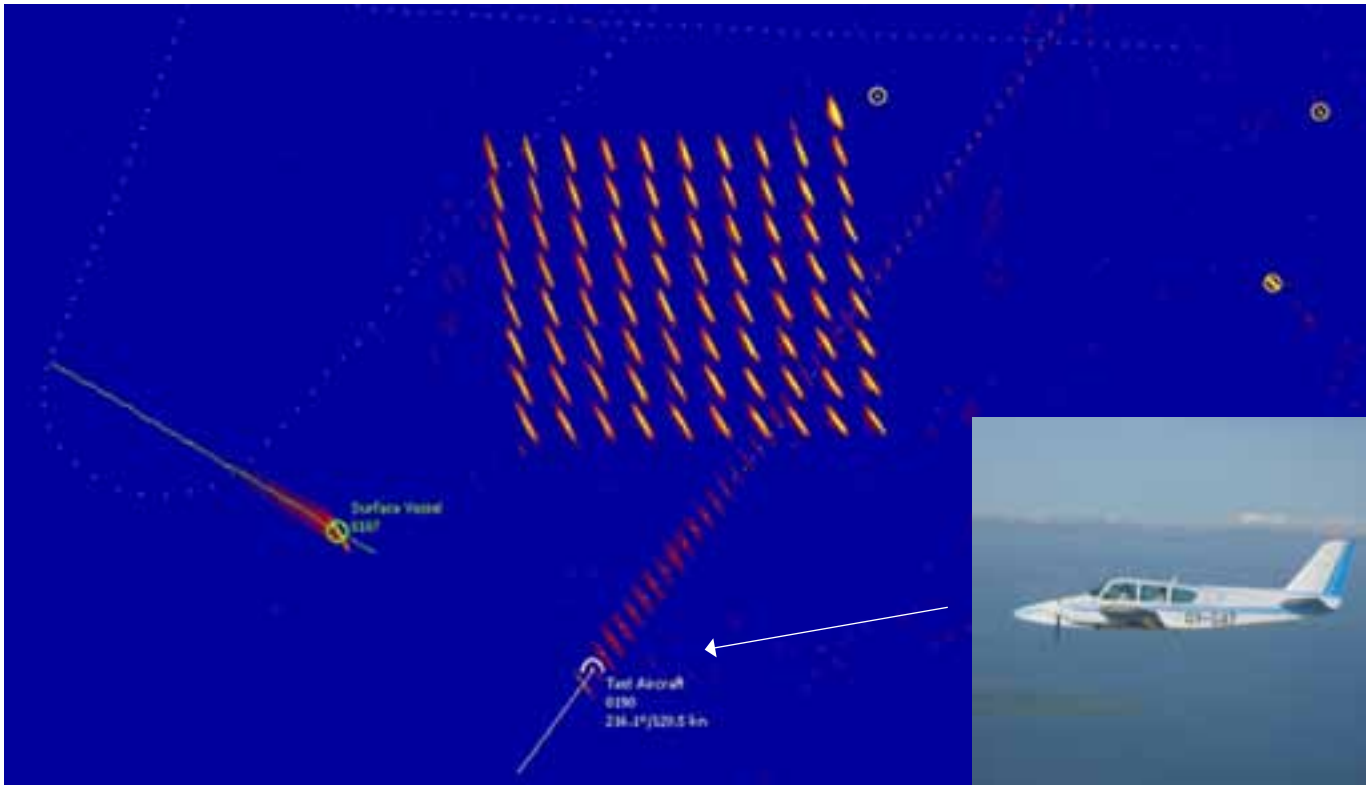
SCANTER 4002

The SCANTER 4002 Transceiver is designed for detection and separation of small air targets and large surface targets like wind turbines. To achieve simultaneous good performance for air and surface detection, the SCANTER 4002 radar system is designed as a 2D coherent X-band radar with pulse compression and advanced MTI-processing, which provide enhanced detection of small air targets.

Inter-turbine visibility

The high transmit power and receiver dynamic range (+110 dB) of the SCANTER 4002 combined with low range and antenna side lobes give superior detection of small air targets, like e.g. general aviation aircraft and helicopters, without degraded sensitivity in and around the wind farm. High resolution CFAR processing enables target detection and tracking between turbines.

Utilizing state-of-the-art processing technologies, the SCANTER 4002 enables efficient and cost effective detection of even very small targets.
The instrumented range of the SCANTER 4002 air coverage is up to 100 NM and the Radar System can be configured with different antenna systems, e.g. 15ft, 18ft or 21ft, depending on the requirements.



Small test aircraft (Grumman GA7) in and around Horns Rev1 offshore wind farm.

Terma Airborne System Expands Business Area to Include South America

The Chilean Air Force has awarded Terma a contract to upgrade Electronic Warfare System on F-16's. The aircraft in question are ex-Netherlands F-16's that were already equipped with the Terma Electronic Warfare Management System AN/ALQ-213(V), and now needed a software upgrade,

The contract is for the first batch of Midlife Upgraded (MLU M2) aircraft and the upgrade has already successfully passed all testing, which in turn has led to a requirement for a similar task for the M4 batch of F-16's for which Terma has just been awarded a similar contract for software development.

Matured Decision Support and High Fidelity Embedded Training - a Vision Come Through

By Andy Gittins

Foresight of founding fathers paying off

Since Terma's Electronic Warfare Management System, EWMS, was introduced on the F-16's of the European Participating Air Forces, EPAF, in the mid-1990'es, the ambition has been to make the F-16 the best prepared aircraft for the EW challenges of the 21st century, The fathers of the EWMS had the foresight to build in potential for the future. For example, they built in numerous interface and processing resources not necessary at the time but meant for future upgrades .

This foresight has proven invaluable making it possible to introduce enhancements that ensure a seamless adaptation of the EWMS to the operational requirements of the 21st century.

For the EW Management Unit, EWMU to provide more operational value, any automation would need to match very carefully tactics applicable to a military aircraft. Therefore, since 2004, Terma, with EPAF national specialists, has been developing a new decision support solution for the EWMU Electronic Combat Adaptive Processing, ECAP. In the same time frame, new EW Sensor/Countermeasures technology also supported the need for more automation/coordination between sensors and countermeasures.

With the new decision support and new EW subsystems capabilities, enabling the end users to familiarize themselves with how to operate and get the best out of the EW suite, in the context of "war", it was clear that this could not be achieved through traditional methods. For example, in-flight engagements against real threats (airborne missiles and full weapon systems), while training, is neither practicable nor possible. Therefore, Terma proposed to provide "full EW Sub-system Simulation" for un-installed EW subsystems

Cockpit Installation: Advanced Threat Display merges all real EW information with ECAP's decision support information along with Embedded Training's Virtual Threats and Simulated Sub-systems.

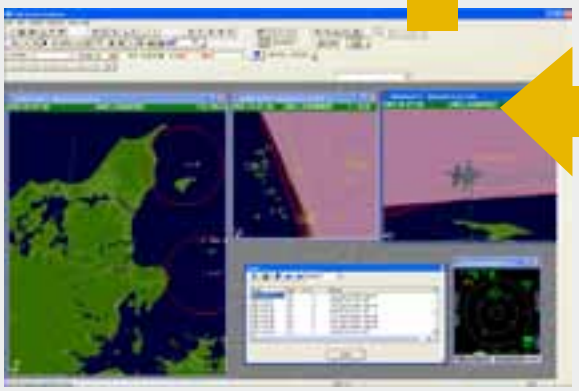
and provide "Virtual Weapons Systems" against which weapon tactics could be trained. This capability combination is known as Embedded Training, ET.

21st Century challenges call for flexible approach

The level of risk and investment in new EW capabilities that air forces are able and willing to take in the 21st century are generally not the same as those seen in the 20th century. Therefore, in order to extend capabilities of the standard EW Management Unit, EWMU, it was necessary for Terma to take measurable, iterative steps to develop and demonstrate new capabilities. This approach ensured that the developments took the correct directions and if necessary tweaked along the way. The roadmap of development, test and evaluation has now led to a solution that, here in 2011, can supply matured decision support and high fidelity embedded training. »

Program/update: 1) simulated weapon system models, 2) locate virtual threat sites on map, and 3) upload training senario to on-board ALQ-213 management system

Select ALQ-213 Embedded Training mode in-flight - virtual threats will appear as if they were real – simulated countermeasures and pilot responses will be recorded



In-flight recording uploaded to pilot debrief system for analysis and lessons learned

Realistic training – during every flight – be better trained and prepared for combat

Iterative development strategy calender

The calendar of events was as follows and demonstrates the methodology of converting a big picture vision into a truly valuable asset to the F-16 EW community. The whole development project was conducted in two partly overlapping phases, with phase 1 being a demonstration and learning phase and phase 2 the actual implementation of the total package consisting of Electronic Combat Adaptive Processing, ECAP and Embedded Training, ET.

Phase 1 activities:

2004-2005 demonstration project:

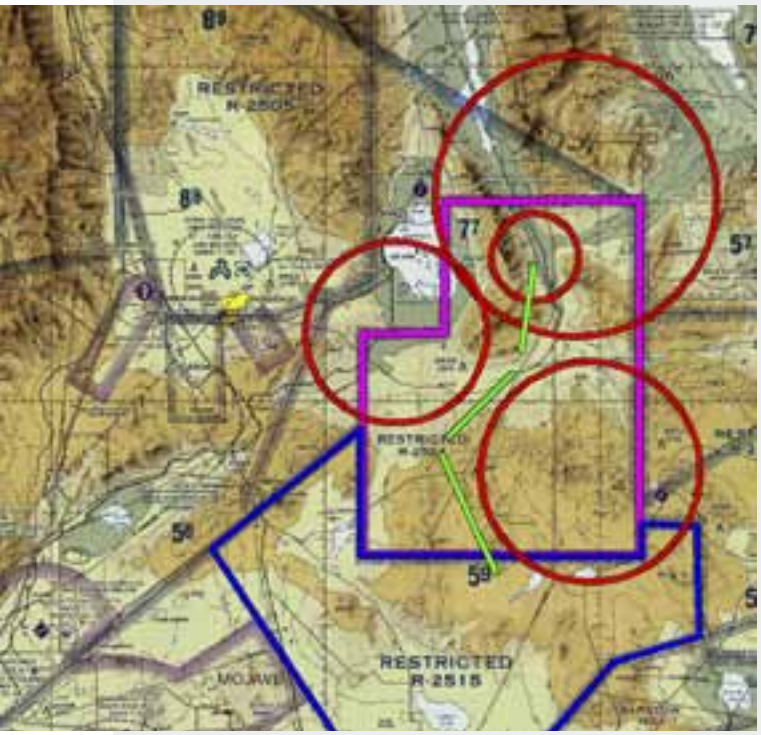
Terma and the RDAF teamed to allow Terma to demonstrate its latest capabilities. The aim was to install and allow for RDAF evaluation.

Terma demonstrated in 2004 that the RWR Azimuth indicator and EWPI could be replaced by a EW information Multi-function Color Display called the Advanced Threat Display, ATD. This was installed and flown by the RDAF. In addition, 3D Audio for Missile Warning Alert tones and Radio Separation was demonstrated.

Virtual RWR and MWS threats were displayed on the ATD to show symbology capability of ATD and stimulate the 3D Audio for test/evaluation/PVI analysis.

Basic automated decision support was added to show that MWS alerts could produce "real-time" optimized dispense programs and that pilot workload could be reduced by automated EW subsystem control.

Virtual Threat Engagements with EW countermeasure feedback processing proved with sufficient detail that



Global Embedded Training Evaluation: Map illustrates training scenario at Edwards training area in California. Other parts of the evaluation took place in Portugal, The Netherlands, Denmark and Norway.

Terma's in-flight PC Tactical Data Unit, TDU, could handle the processing and instrument all virtual EW processing.

The confidence gained from the demonstration project's flight test results enabled the European F-16 EWMS EW Management System, user group to engage in a full development program for ECAP and ET with the F-16 M5 upgrade program.

2006-2010 F-16 M5 EWMS upgrade development program :

The ET and ECAP capabilities are sophisticated in concept and to ensure that the End-User network (aircrew and ground staff) could support the capabilities new EW Mission Support capabilities were required. It was also identified that to exploit the ET to the maximum, full pilot debriefing with EW should be provided. This was achieved by the F-16 EWMS and F-16 Mission Planning User Groups teaming up so that the NAVAIR PC Debriefing System would be able to integrate with Terma's EW debriefing facilities.

The TDU provides the end users with a capability of

- Loading EW related mission data
- Recording EWMS processing in-flight data
- Reporting maintenance requirements

To make use of these capabilities, Terma developed a new EW Mission Support Tool application capable of providing all the required pre-mission data generation, TDC management and post mission analysis.

By combining the EW Mission Support and In-Flight OFP capabilities, the resulting ET and ECAP provide "Total Packages" so that the Air Forces can extract the very best out of the capabilities.

- For the ECAP, this would be full data library editing, in-flight processing with instrumentation and then post-mission analysis tools for lesson learned activities.

- For ET, this would be full "virtual" threat model parametric editing and "virtual weapon engagement scenarios" editing, in-flight processing with instrumentation, and, for lesson learned activities, post mission Pilot Debrief and EW specialist analysis with replay.

Phase 2 activities:

The second phase of the project "Total Package - ECAP and ET", was to ensure that the end-user could evaluate progress with flyable software and associated ground support facilities. These projects' OFP tapes were labelled P06A and P06B. **2006-2007 OFP Tape P06A** was used for ATD PVI development, developing the framework of ET and a demonstration of the Mission Support Tools.

2008– 2009 M5.1 Early Operational Assessment (EOA) Leuwarden -M5.1 Edwards Development Trials (DT) — M5.2 (Operational Test and Evaluation) OTE Ørland. Flight trials were performed and the anomalies and maturing of requirements fed into the P06B upgrades with special focus on ET "RWR Realism".

2009-2010 P06B-ET and ECAP were used to conclude the complete package for ET and introduce ECAP. The ECAP capabilities were for pilot "EW workload reduction" and ECAP automated decision with advanced RWR for Automated Countermeasure Responses.
Pre-mission editors for ECAP and ET and full integration with PCDS for EW debrief including ET were also provided.

Combat proven

The "Total Package" was then worked through at Edwards Air Force Base, CA and at National Operational Test and

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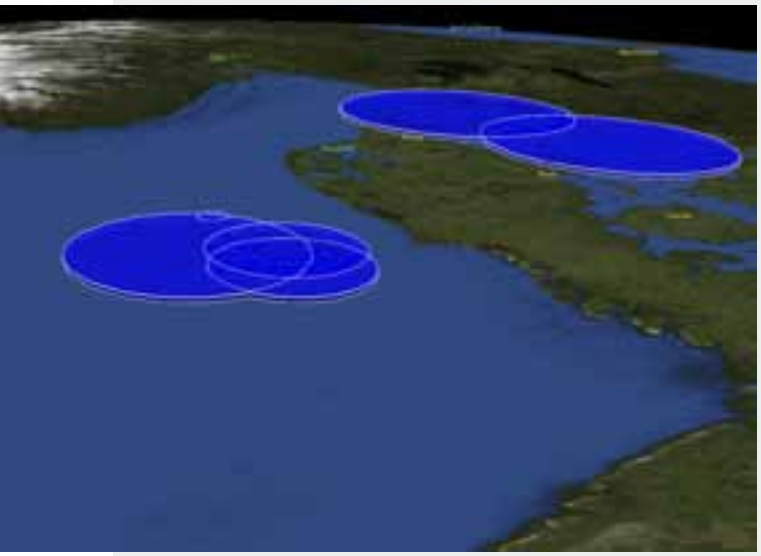

Training areas included Portugal, The Netherlands, Denmark, the North Sea and Norway.

Evaluation exercises. Here the Embedded Training level of reality was actually exceeding customer expectations.

This tape is now in combat and the support tools now provide abilities towards EW Analysis/Pilot Training that means that the pilots are better prepared and the level of survivability has been raised.

This is truly a success story, but it doesn't end there, there is always a "Sequel".

The Follow-On Tape P07A

But with all new concepts once things get used and pilots get excited, requirement extensions appear. This has led to a tape called P07A. The big focus here has been even more ET RWR reporting realism, improved pilot decision support, user interaction and then one nation activated ECAP (Level2) which enables "decision support analysis" of the RWR Threat environment picture with optimized responses.

M6.1 Early Operational Assessment, Denmark and Portugal

The objective here was to allow the complete military end-user communities to assess the effectiveness of the aircraft in flight but also the associated ground support software.

Due to the nature of coordinating EW assets and staff and the latest Terma SW, the Air Forces actually used this EOA as an opportunity to assess both the current (M5) and the new phasing-in (M6) solutions. Terma was represented by senior EWMS F-16 specialist engineers to support, advise and coach both ground EW specialists and the pilots to explain in-flight capabilities. All nations along with the Terma staff, drove the usage of the EW suite to new limits and especially the new mission support tools, which allowed for analysis of anomalies to be addressed with a "new pace" unseen at any previous EW trial, which was seen as incredible considering the new level of complex capabilities added to the EWMS

What can ECAP do for you?

The principle concept of ECAP is to give every pilot an additional "backseat EWO" with the best EW experience of their mission's real-time threat picture, pre-mission intelligence information and the best knowledge of the EW subsystems (warts "n" all). Then as a bonus, "the traditional in-flight decisions can be worked through at 1G with a cup of coffee rather that in the heat of engagements at 5G" (pilot quote). In-flight, the pilot is given the opportunity to consent or

decline the ECAP decisions, but also ECAP assesses the system wide threat picture through Threat Tracking algorithms. This is relayed to the pilot through ATD Symbol enhancements and audio prompts. Depending on pilot workload/phase of mission, the pilot can operate in Semi-Automatic or run in Full-Automatic.

Terma has worked very closely with pilot/EW community so that the focus is to balance "Decision Support" with "Automation/optimization of actions". To cover these needs, ECAP is fully programmable (by the EW end-user community) through Windows based Software Tools. ECAP processing is instrumented during flight and so a Post-Mission Analysis Package is available to assess ECAP mission effectiveness so that the"lessons learned" principle can be applied.

What does ET do?

ET is there to train Electronic Combat tactics against ground based threat systems and keep pilots familiarized with their complete EW suite. The ET scenarios can be modified through mission data from "procedural" to "full mission context scenarios".

The in-flight capabilities include

- Simulation of non-installed EW subsystems, e.g Radar Warning Receivers, Missile Warning Systems , multiple RF Jammer Types
- Virtual "Smart" ground Threats with programmable doctrines
- Performance models of Sensors and Countermeasures
- High Fidelity RWR threat report realism
- Computes and evaluates performance in 3D

The associated ground support capabilities include

- Weapons System models—Parametric editing
- Scenario Generators
- Pilot Debrief with EW of Embedded Training within PCDS
- Post-Mission EW analysis of ET for "lessons learned"

In-flight, the pilot can select ET scenarios and then experience the Virtual engagements. The ET operates seamlessly through the ATD, EWMU and 3D Audio, so that the ET threats can merge with the real system threat picture. In addition, the ET threats can be processed by ECAP so that the pilot gains a full **"We Train as we Fight"** experience.

Although ECAP and ET testing was carried out within the F-16 community, results are equally applicable to other types aircraft equipped with the ALQ-213. In-fact the capabilities have been designed with core processing and mission data strategies, which mean tailoring and re-integration to other aircraft platforms are minimised. Transfer of these capabilities onto other platform types within the ALQ-213 user community has already been initiated.

Five country development, test and evaluation program

Financial Highlights

USD million	2010/11	2009/10	2008/09	2007/08	2006/07
Revenue	250	210	203	195	171
Equity Capital, year-end	68	62	72	83	62
Assets, total	281	276	258	215	173
Order intake	246	165	230	270	163
Order book, year-end	283	308	359	325	227
Number of full-time employees – Average for the year	1,200	1,261	1,183	1,020	965

Terma in Brief

Terma's Business Areas cover:

- **Aerostructures:** Development and production of advanced structures for defense and non-defense aircraft and helicopters

- **Integrated Defense and Security Systems:** Network and tactical systems, airborne and naval self-protection systems, and electronics manufacturing services for mission-critical defense and security applications

- **Radar Systems:** Advanced radar systems for coastal surveillance, naval surveillance, vessel traffic surveillance, perimeter surveillance, and surface movement surveillance at airports

- **Space:** Mission-critical products, software, and services for space applications

Terma develops and markets high-tech solutions, systems, and products for defense and non-defense applications. Our products are developed and designed for use in extreme mission-critical environments and situations, where human lives and valuable material assets are at stake.

Terma A/S was established in 1949, is headquartered in Denmark, and maintains international subsidiaries in a number of European countries, the US, and Singapore.

For many years, Terma has worked closely with the Defense, public authorities, and international organizations around the world. Extensive dialog and meaningful relationships with our business partners give us an in-depth understanding and appreciation of their strategic, functional, and management needs.

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